# 1. IC4.2 Part 2: Applying Climatic Anomalies to EPS Data

**Instructor Notes:** Hello, my name is Richard Grumm, in this module we will examine using climatic anomalies to forecast winter storms.

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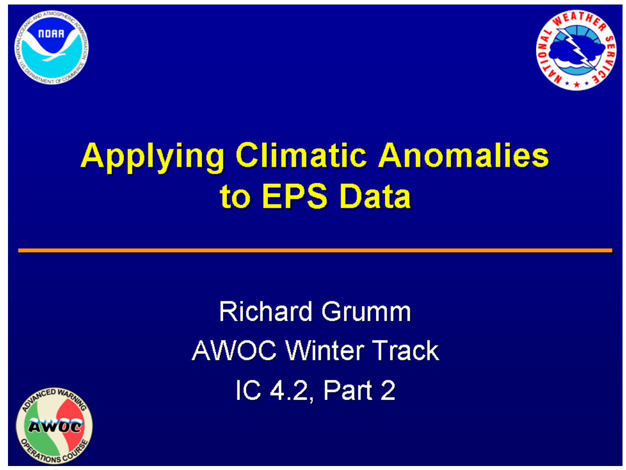


# 2. Objectives

**Instructor Notes:** We will determine what anomalies are significant in winter storms. Some local and regional research may be required to refine this for your forecast area as what we show here may not apply to your area of responsibility. We will look at a forecast, and examine some of the problems one might encounter using anomalies with model or ensemble prediction data.

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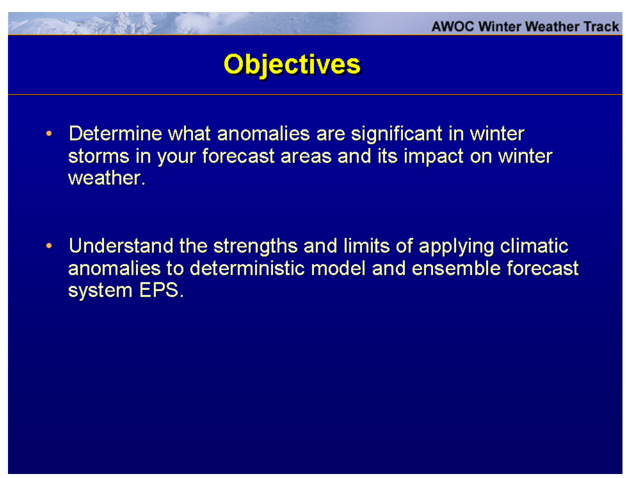

# 3. Case Study Applications Using GR Data

**Instructor Notes:** We will take a case study approach using Global Re-analysis data (GR). This talk cannot address the concerns of all users as the proximity of oceans and terrain will dictate which anomalies are important to you. Clearly, in along the Pacific coast, southwesterly winds and high pwat into the terrain are going to be big signals in winter precipitation events. Wes Junker, with some help from a cast of many is working on this specific issue. You can learn by case studies with GR data…re-running the WRF against data for some of your favorite cases. Our focus is on anomalies with winter storms. We will use two cases showing re-analysis data and one using Ensemble data. We will look at some examples and harness 7 years of using these types of data.

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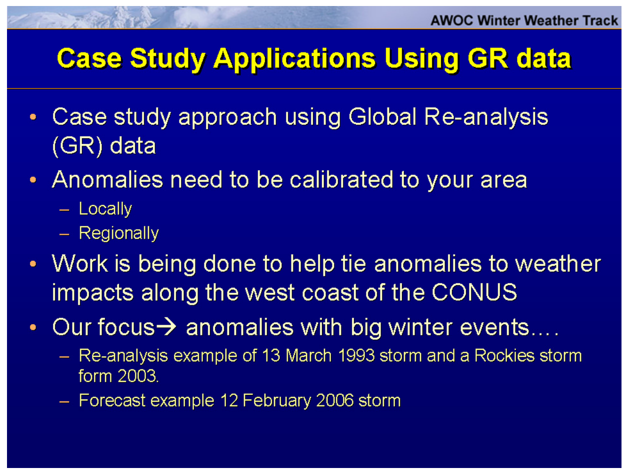


# 4. Key Fields Super Storm 1993 0000 UTC 13 March Low-Level Jet: Big Precipitation Event

**Instructor Notes:** Our first case is the Super storm. It had lots of anomalies and the type we associate with major East Coast Winter storms (ECWS). Things of note from Kocin and Uccellini (2004 book), Grumm and Hart (2001) and Stuart and Grumm (~2006) include: deep strong surface cyclone, strong low-level easterly flow ahead of the low, strong southerly flow in warm sector to transport moisture. Easterly flow east of Rockies is a common method to get moist air into play for regions including the upslope from the front range all the way to the east coast. In the western Plains and eastern Rockies you may have to use 700 hPa winds instead of 850 hPa winds.

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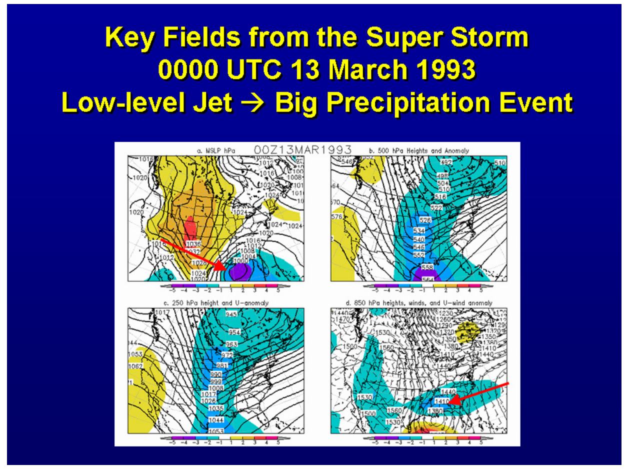


## 5. 0600 UTC Strong 850 hPa V-Winds: Florida Severe Event

**Instructor Notes:** You can see the anomalous sea level pressures (>5 SD below normal). The anomalous 500mb height anomaly is in the upper right panel and the lower left panel shows the very low 250 mb height anomaly. In the lower right, very strong V-wind positive anomalies of > 5 standard deviations indicate much stronger than typical southerly low-level jet.

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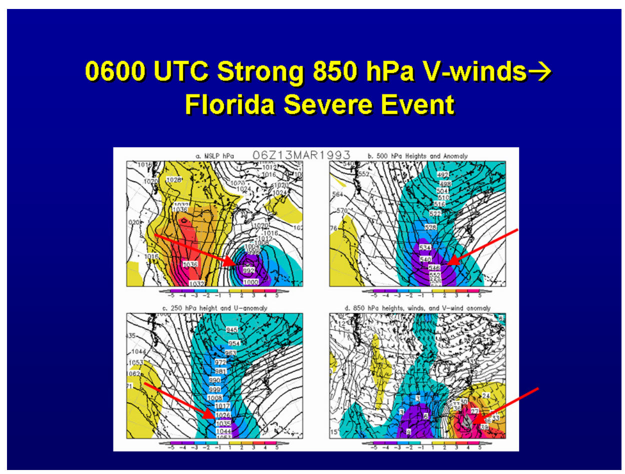


## 6. 1800 UTC Deep Low with Big U-Wind Anomalies in PWAT Gradient: Big Snow

**Instructor Notes:** The anomalies got out of control as the storm developed and deepened. We say areas of 5 Standard Deviation departures from normal. Our surface cyclone was over 5 SDs below normal in the GR data. Note the strong U-wind anomaly on the cold side of our cyclone in the general region where the heavy snow was observed.

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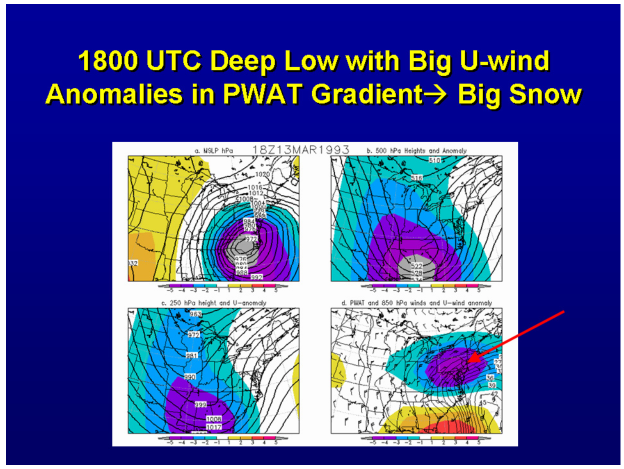


# 7. 0000 UTC 14 March-Big Snow in U-Wind Anomalies and PWAT Gradient

**Instructor Notes:** The large anomalies continued as the storm moved up the coast. The classic anomalous low-level jet in the cold air is clearly visible. This storm had many large anomalies. Model re-runs showed similar anomalies with this storm. In the future, we hope to run the WRF off the NARR data to see how large the forecast anomalies may have been compared to 32 km rather than 2.5 degree data.

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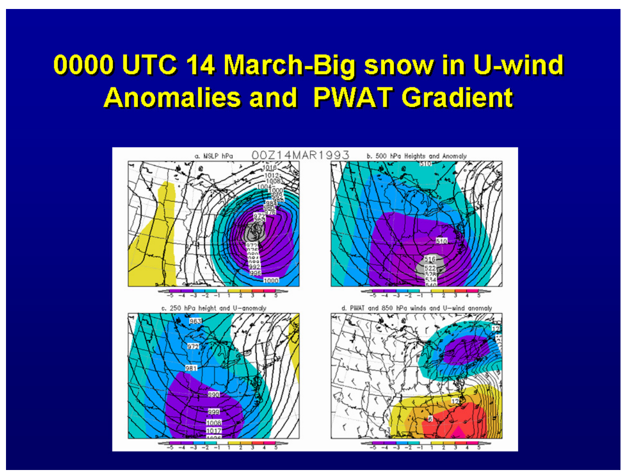


# 8. Rocky Mountain Region Snows

**Instructor Notes:** Work is still progressing relating the anomalies to weather in the Rockies. These following storms did have very large negative U anomalies at 700 mb. Oct 25-27, 1997 March 3-5, 1990 17-20 Mar 2003. We will look at the March 17, 2003 storm. Anomalies work in the Rockies too using the GR as an example…

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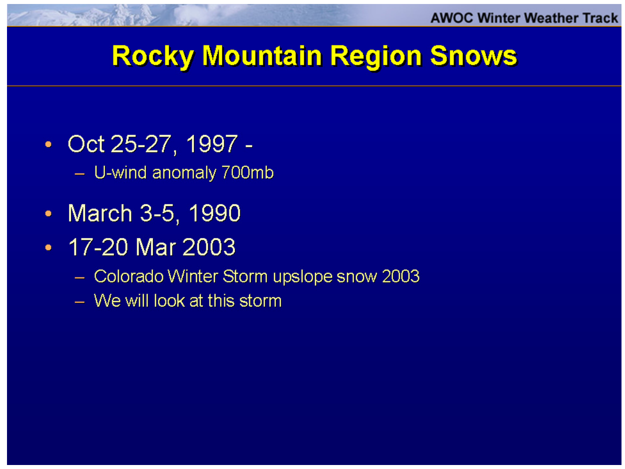


# 9. Colorado Winter Storm Upslope Snow 17-20 Mar 2003 Several Feet of Snow

**Instructor Notes:** We will examine a particularly big snow storm. It has the same U-wind anomalies as the ECWS's show…but sometimes you have to look a bit higher such as 700 hPa. This u-wind anomaly issue is not unique and was observed and forecast in a big Oct. 2005 snow in eastern MT and ND.

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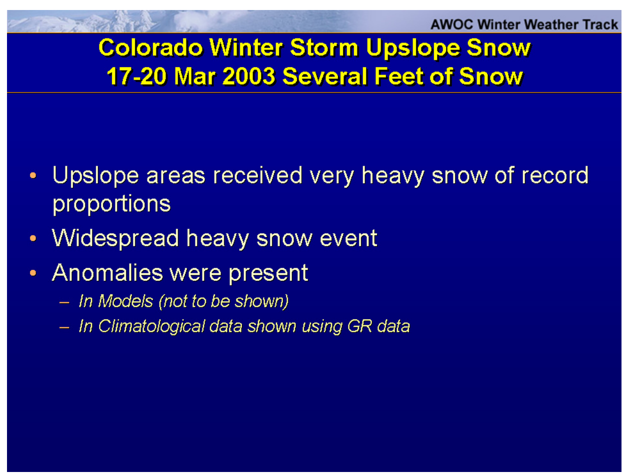


# 10. 700 U-Wind Components (U-Wind) and Precipitable Water

**Instructor Notes:** The 4-panel charts are laid out similarly to the 13 March, 1993 storm along the east coast, however we use the 700mb U wind anomaly. You can see the lower right panels of both times, a strong negative 700 mb U wind anomaly that corresponds to the easterly upslope component of the wind. The 06 UTC chart shows -5 SD values indicating how unusual it was to get easterly 700 mb winds of that magnitude. Those easterly winds were transporting high Precipitable Water (PW, black contours) upslope. The upper right panel shows an anomalously deep closed low at 500mb and anomalously high heights in southern Ontario implying the unusual nature of getting a blocking pattern of this strength. We see the classic large anomalies in the GR data.

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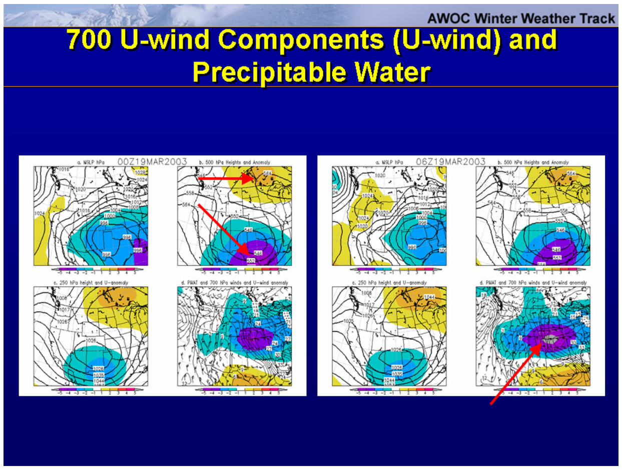
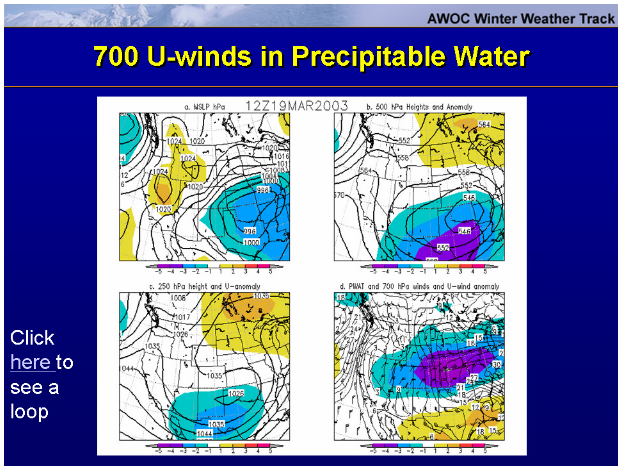



# 11. 700 U-Winds in Precipitable Water

**Instructor Notes:** Here is a closer look at the 700 mb U wind anomalies and the precipitable water values.

**Student Notes:**




# 12. Winter Storms in Rockies

**Instructor Notes:** Some general forecast rules and implications for the eastern United States. These actually apply to heavy precipitation events in general too. Advance this slide manually.

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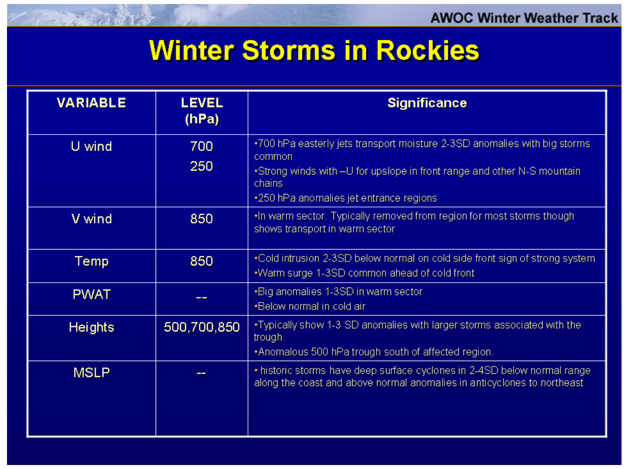


# 13. Case Study: 11-12 February 2006

**Instructor Notes:** So let's apply all these anomalies to forecast data. We will use the 11-12 February 2006 ECWS and focus on ensemble prediction system (EPS) data. Why EPS data…there was, and nearly always is, uncertainty in the forecasts. This keeps the anomalies lower at longer ranges compared to a single deterministic model. But the lower values are due to real uncertainty and big anomalies in a single model may cause the forecaster to get too optimistic. In this case…the storm was not well forecast beyond about 5 days. It appeared with the 12Z 8 Feb 2006 GFS though it was in the 00Z 8 Feb and 06Z 8 Feb MREF…as more of a near miss in most members. SREFs had some problems with SREF-ETA members. Storm "appeared" on 8 February in GFS so limited lead time MREFs did a bit better than GFS We will show a mix of MREF and SREF data for brevity.

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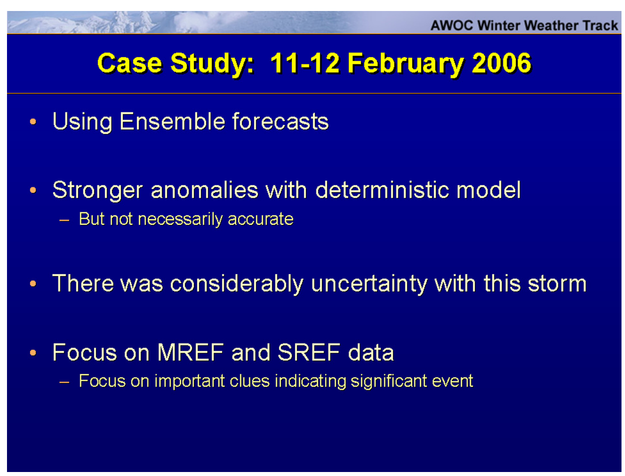

## 14. Snow Fall 26.9 Inches in Central Park, NYC

**Instructor Notes:** Here is a snowfall image. There were some 20+ inch amounts, and NYC had a record snowfall of 26.9 inches which set the all-time record for snowfall. There were some intense bands, but those are mesoscale details we will avoid.

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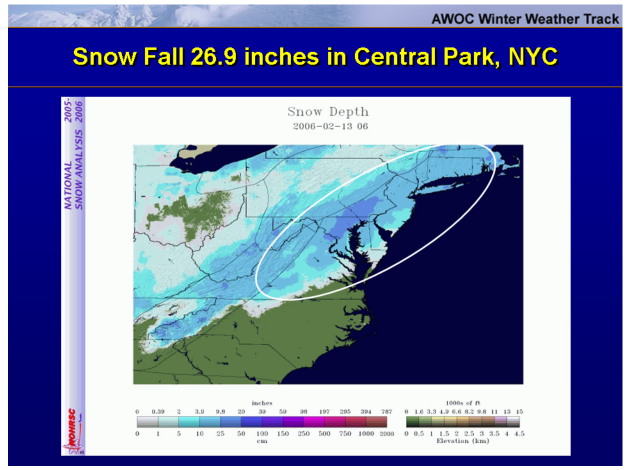


## 15. MREF MSLP and Anomalies: Big Storm Potential

**Instructor Notes:** These data are from MREF forecasts initialized at 06Z and 12Z 8 February, 2006. Quite early on the GFS was not really predicting much of a storm yet, but the MREF showed a big storm. scooting just off shore, a near miss of an anomalous storm. We will ignore the spaghetti plots at the top of each image. Suffice to say they show us that there was considerable uncertainty in these forecasts. The ensemble mean MSLP forecast on the lower right side shows a deep surface cyclone and a strong anticyclone to the west. These two features have been associated with major East Coast winter storms. Between them we can infer strong cold advection. The intrusion of cold air is another important predictor of major East Coast storms. The MREF initialized 6 hours later showed a deeper storm closer to the coast implying an increased threat of a winter storm. Our key point here is that the ensembles predicted a storm and a storm that would have a cyclone with below normal pressure, a characteristic of a major storm.

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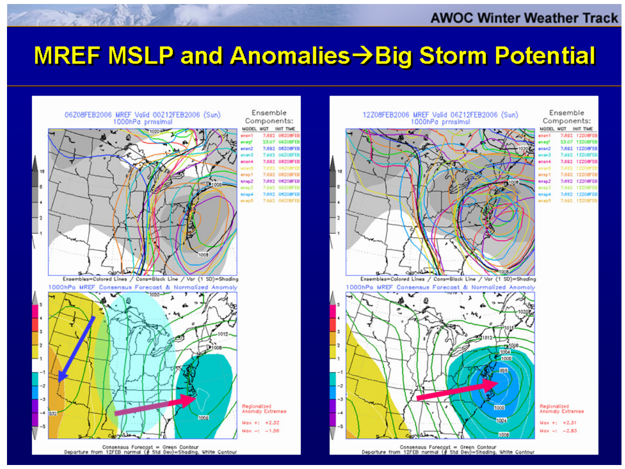


# 16. SREF 2100 UTC 9 Feb. Anomalous LLJ

**Instructor Notes:** We quickly move to SREF data the next day. MREF data showed similar features, but we want details fast in our case study. The upper panels show the 850 hPa winds and U-wind anomalies. The lower panels show the same winds but Vwind anomalies from SREF forecasts initialized at 21 UTC 9 February 2006. One thing we should note is that forecasts from this time were the most optimistic for heavy snow farther west and a more westward cyclone track. The purple values are very large anomalies which have been shown to be associated with areas of strong FGEN and banded precipitation. These features are common in nearly ALL major ECWS's. We can see the anomalous easterly jet north of the low and the southerly jet in the warm sector. Most major storms have both anomalies. The strong southerly jet is important in bringing moisture into the system. Later forecasts show the focus of the anomalous low-level jet over southern New England, NY and NJ. These areas did see very heavy snow. We can also see our southerly wind anomaly in the warm sector at this time. If we compared these anomalies to a single EPS member, the NAM or GFS we would find these anomalies are low because: we are using an ensemble mean, disagreement among members...uncertainty reduces the winds and spread the wealth to a larger area.

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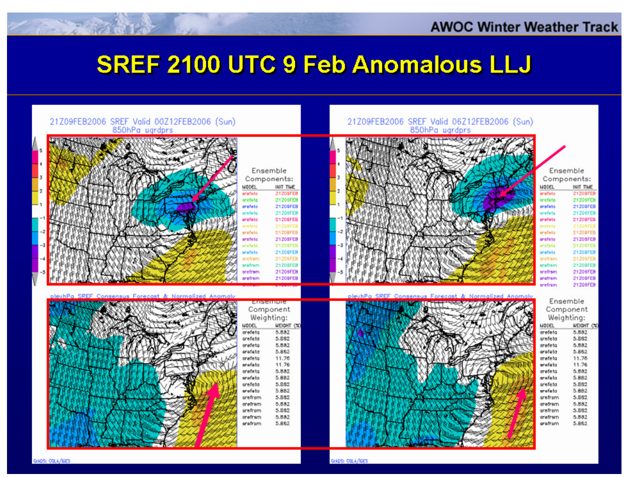
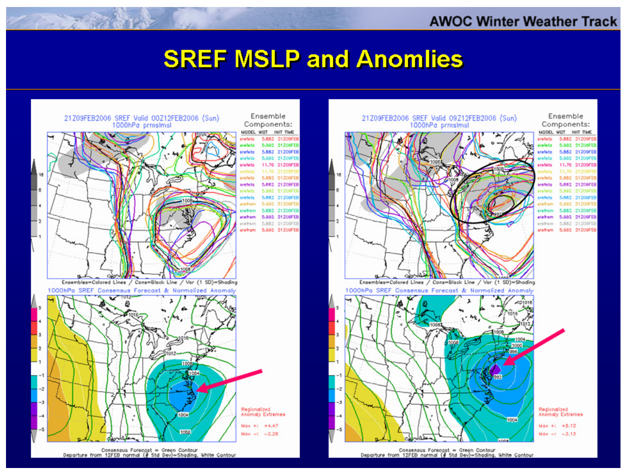


# 17. SREF MSLP and Anomalies

**Instructor Notes:** These images show the MSLP evolution. These are SREF images and the upper panels show the spaghetti plots. Note there is considerable uncertainty in these forecasts as indicated by the shading showing the spread of the field indicated by the shading. The differences in the forecasts limit or reduce the anomaly values relative to a singe deterministic model. We will focus on the anomalies in the lower panels. Note the earlier forecast shows an anomalous MSLP center over North Carolina and Virginia. Also note the anomalous anticyclone (yellow) to the west. The later forecast, on the right shows even a deeper surface cyclone. There is an implied strong easterly wind north of the surface cyclone. These SREF data 32km data compared to very coarse GR anomalies. We might gain more using NARR data in the future. The key here is that our SREF system predicted a mean pressure field that indicated a cyclone with MSLP values showing an anomalous surface cyclone.

**Student Notes:**




# 18. 2100 UTC 10 Feb. 2006 SREF MSLP

**Instructor Notes:** In these images we have moved forward 1 full day…the SREF's are now initialized at 2100 UTC 10 February. There is less spread in the MSLP forecasts as the uncertainty decreases with shorter forecast length. Thus, we see larger anomalies in our MSLP fields associated with our surface cyclone in the lower panels. At this time, our surface cyclone is now forecast to remain just off shore…reducing the threat of heavy snow farther to the west. But our focus is on the storm and the climatic anomalies and not the details of the inherit uncertainty in weather forecasting. We can clearly see that the SREF ensemble mean was able to predict an anomalous surface cyclone along the east coast. A single deterministic model or single SREF member would likely have shown a more anomalous cyclone, but then we could not account for the uncertainty. Still the SREF forecast an anomalous surface cyclone.

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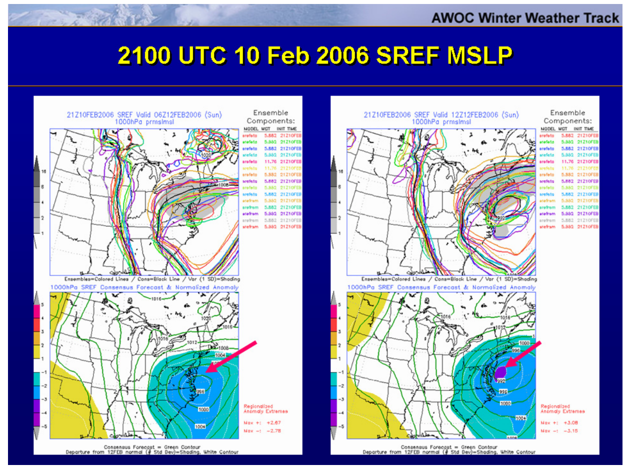
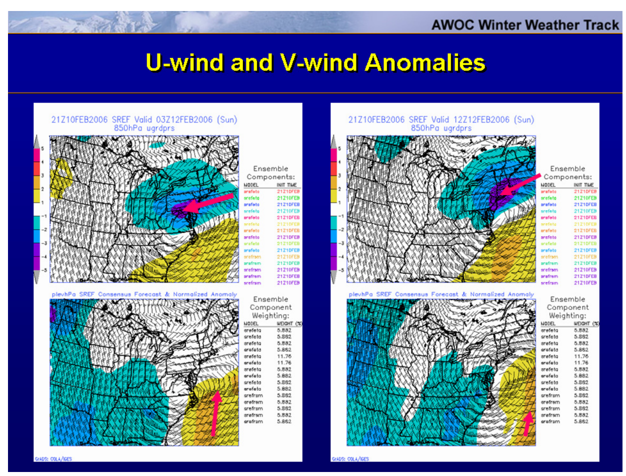



# 19. U-Wind and V-Wind Anomalies

**Instructor Notes:** The data in these images were initialized at the same time as those on the previous slide showing MSLP forecasts. Relative to the previous 850 hPa wind forecasts, the low level jet gets finer and more focused as we get closer to the event time. Thus the anomalies are a bit larger. Smaller differences in EPS members lead to larger and more focused anomalies at shorter forecast ranges. But not as detailed and strong as one might see using a single member or forecast model. We still see the anomalously strong low-level easterly jet north of the cyclone in the area of heaviest snow. We can also see our southerly wind anomalies in the warm sector. These features are associated with nearly all major East Coast Winter storms.

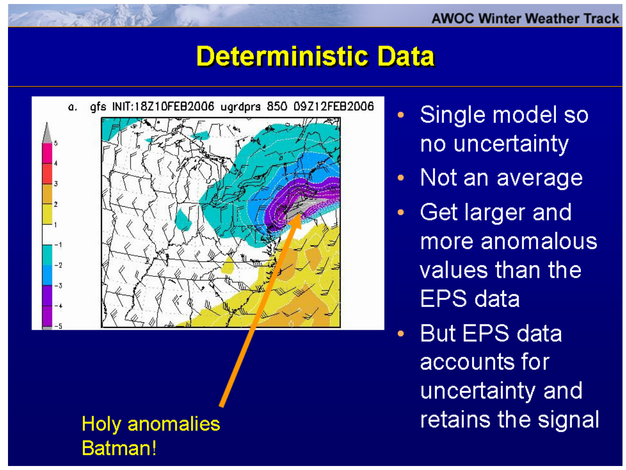
**Student Notes:**




# 20. Deterministic Data

**Instructor Notes:** Okay, here is the GFS a single model, so you visualize the much larger u-wind anomalies. All uncertainty is removed, though there is not accounting for model accuracy, and the single forecast shows the strong jet. We could show similar examples of MSLP and 850 hPa temperatures, but the results would be the same. Using ensemble data you get a slightly reduced signal. A single EPS member or model provides a feel of how strong the real LLJ may be, but a false sense of exactly where it may be!

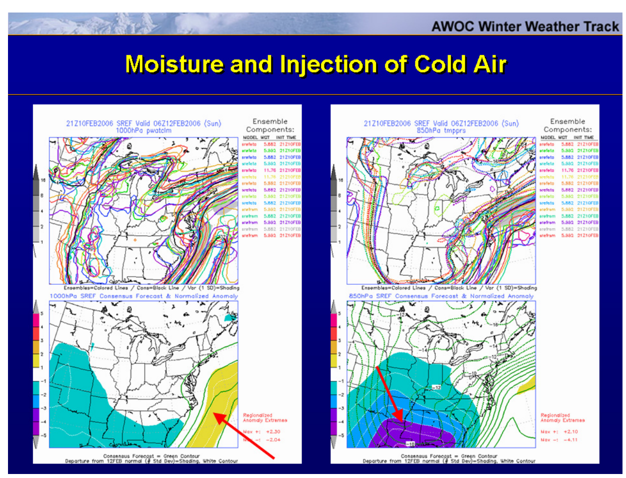
**Student Notes:**




## 21. Moisture and Injection of Cold Air

**Instructor Notes:** MSLP anomalies and U and V wind anomalies are not the only anomalies of value in forecasting winter storms. Other key fields include moisture which we will show using precipitable water (PWAT). We can see the moisture anomaly with our storm over the western Atlantic in the lower left hand panel. This is in close proximity to our low-level southerly jet. Thermal anomalies are also important. An intrusion of cold air is typically observed to the west of our surface cyclone and is important in the cyclongenesis. In this case, we can see the intrusion of very cold air into the central Gulf States as forecast by the SREF. The case lacked the strong positive thermal anomaly often observed in the warm sector of many major and significant East Coast Winter Storms.

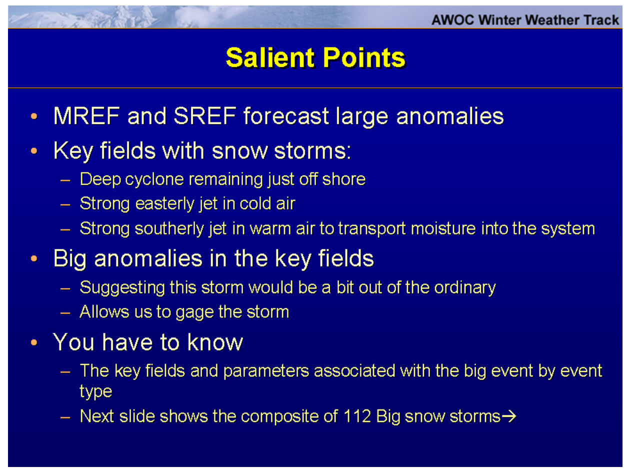
**Student Notes:**



# 22. Salient Points

**Instructor Notes:** MREF and SREF forecast large anomalies. Key fields with snow storms: Deep cyclone remaining just off shore, strong easterly jet in cold air, strong southerly jet in warm air to transport moisture into the system, big anomalies in the key fields, suggesting this storm would be a bit out of the ordinary and allows us to gage the storm. You have to know the key fields and parameters associated with the big event by event type. Next slide shows the composite of 112 big snow storms.

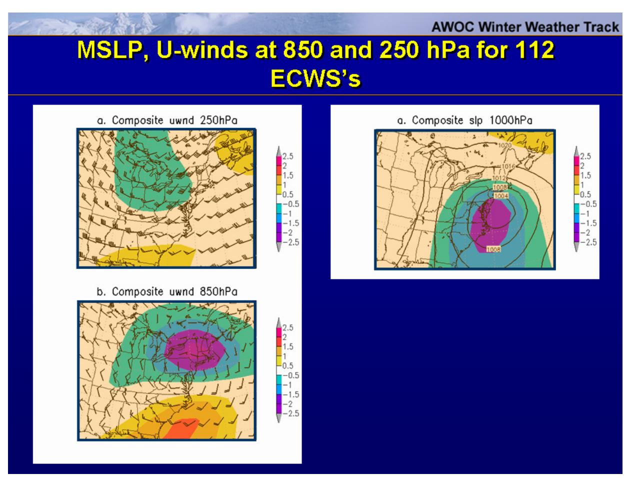
**Student Notes:**




# 23. MSLP, U-Winds at 850 and 250 hPa for 112 ECWS’s

**Instructor Notes:** These images show some of the key features with major ECWS's. We found about 112 cases and composited them. The data showed a deep cyclone just off shore and a strong easterly wind north of the low at 850 hPa. The 250 hPa winds shown suggest weaker than normal westerlies in the upper level jet…its an entrance region. Other features are not shown but many parameters leave a strong signal including that intrusion of low-level cold air at 850 hPa and lower levels.

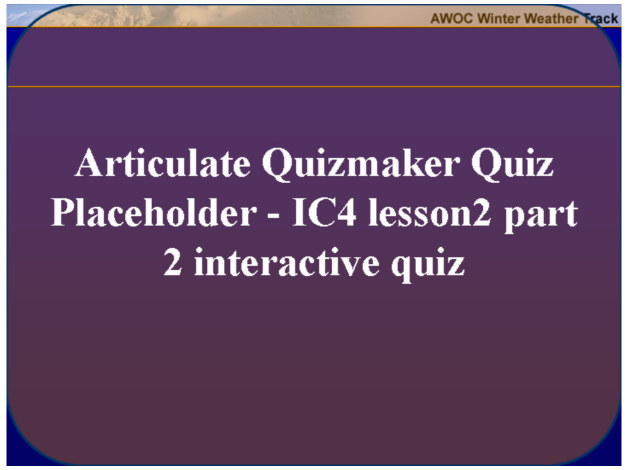
**Student Notes:**



# 24. Winds and Winter Storms and Anomalies

**Instructor Notes:** Take a few moments to complete this interactive quiz.

**Student Notes:**




# 25. Summary

**Instructor Notes:** We showed from the climatic data anomalies with big winter storms in the eastern US and in the Rockies. Moisture and U-wind anomalies north of the low played a significant role in both cases. You need to know the key parameters in your forecast area. We examined a case using EPS data. The exact forecast track changed with time, but the big anomalies were clearly in the MREF and SREF. We get bigger numbers using a single model as EPS data is an average and uncertainty limits the values of the anomalies. Deterministic models give us a stronger signal with big storms but might lead us to get to focused on an single area.

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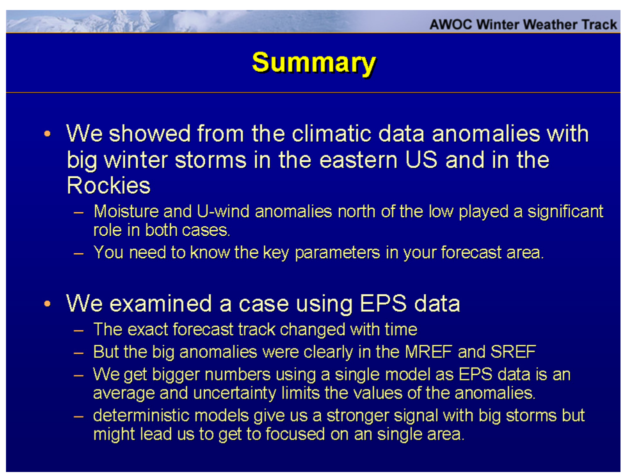
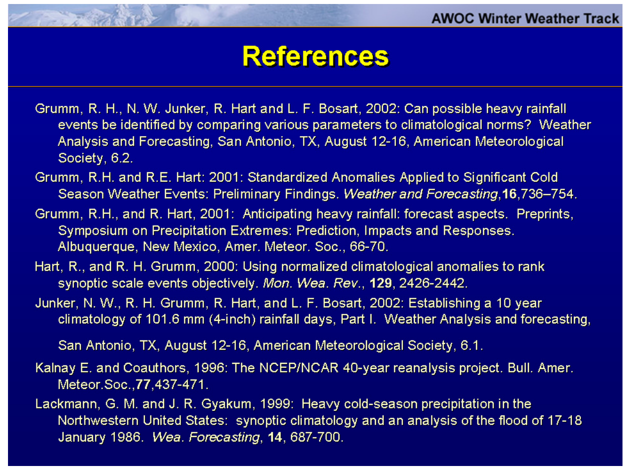


# 26. References

**Instructor Notes:** A few notable references.

**Student Notes:**




# 27. Questions???

**Instructor Notes:** If you have any questions about this lesson, first ask your local AWOC facilitator. If you need additional help, send an E-mail to the address provided. When we answer, we will CC your local facilitator and may consider your question for our FAQ page. We strongly recommend that you take the exam as soon as possible after completing Lesson 3.

**Student Notes:**